is obvious and condemnation of part of the carcase or of the whole, as the case may be, would follow. Such a tubercular change in the worm-nest could not, of course, escape the notice of any person preparing or examining the carcase.

We are greatly indebted to Mr. C. J. Vyner, M.R.C.V.S., Chief Veterinary Inspector to the Department of Public Health, Sydney, for his kindness in supplying us with ample material for our investigations, and with valuable information as to the condition, and also to the three members of his staff, viz., Messrs. Everett and Vidler for obtaining blood films for us, and especially Mr. W. G. Johnston for furnishing much important data and specimens. We would also like to express our thanks to those members of the staff of this Bureau, who have so cordially assisted us in this investigation.

On the Anatomy and Possible Mode of Transmission of *Filaria (Onchocerca) Gibsoni*.

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(From the Government Bureau of Microbiology, Sydney, New South Wales.)

[With Plate XIV.]

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

Filaria (Onchocerca) Gibsoni, Cleland and Johnston, is a nematode parasite which causes the "worm-nests" not uncommonly found in Australian cattle. In another paper[1]

[1] Cleland and Johnston, "On the occurrence of 'worm-nests' in Australian cattle, etc.," *Journ. Proc. Roy. Soc. N.S.W.*, xliv. 1910, p, 156.

we have dealt rather fully with the historical and pathological sides of the subject, whilst in the present communication we propose to deal with the zoological characters of the worm and the possible means of its transmission.

For the purpose of examining the anatomy of the worm in detail, the dense outer fibrous capsule was removed and the complete mass enclosed in its innermost thin capsule was shelled out. This inner capsule was then opened by means of small incisions, and in some cases its contents were carefully teased out at once, whilst in other instances the aids of early putrefactive processes and of pancreatic digestion were used to loosen the connective tissue surrounding the coils of the worm and enable larger portions of the parasite to be extracted undamaged.

An examination of all the fragments removed in this way from individual worm-nests revealed the fact that in many instances apparently only one female worm was present in each, that more rarely both a male and a female were present together, and that sometimes portions of at least two female worms were found. It must be borne in mind, however, that occasionally we entirely failed to extract either end of an individual (owing to the extreme difficulty in removing from its fibrous bed every portion of the worm) from which it will be obvious that the instances in which evidence of the presence of a single worm was alone obtained may really be less numerous than at first sight they appeared to be.

A brief description[2] of the worm has already appeared but we deem it advisable to give a corrected and more detailed account of it here.

General Description.—The body is greatly elongated and closely coiled. As we have stated above, it is very difficult

[3] Cleland and Johnston, "Worm-nests in Cattle due to *Filaria Gibsoni*. Preliminary Report." *Agricultural Gazette N.S. Wales*, xxi, 1910, pp. 173-4.

to extricate the filaria, and consequently its length is not accurately known. We have measured all the fragments obtained by teasing out a nodule from which only one head (a female) was obtained, and found that the total length was 970 mm. Probably the male would be much shorter, as is usual in the Filariidæ. The greater part of the body in both sexes is uniform in diameter; that of the female being from 0·35 to 0·43 mm., whilst that of the male is only about 0·15 mm.

The whole of the cuticle, especially in the female, is ornamented with a very regular series of ridges (fig. 2) which travel round the body in a spiral fashion. There are really two series of spirals as each ridge may be traced to the next but one. This structure appears to be the same as that figured by Railliet[1] as occurring in *Filaria* (*Spiroptera*) *reticulata*, Dies. Each ridge is made up of a series of projections and depressions. Throughout the greater portion of the worm these ridges are very distinct, but anteriorly in both the male and female, especially the former, they become gradually less prominent and eventually indistinguishable. For instance, though very small they may still be seen in the region of the vulva. The following measurements taken from a female worm shew the progressive divergence of the spirals. Just behind the vulva they are very low and numerous, there being about 140 rings in 0·5 mm. This number decreases rapidly until there are 15, then 14 and so on until the usual number is from 6 to 8 in the same distance. In the case of the male there are about 100 rings in 0·5 mm. The ridges here are very small and closely set. The transverse striations figured by Railliet have not been seen by us in *F. gibsoni*. The cuticle, however, is very finely longitudinally striated.

[1] Railliet, Traité d. Zool. Agric. et Médicale, Edit 2, 1895, p. 539, 540; and reproduced in Neumann's "Parasites," 2nd Edit. (English Translation) 1905, p. 552, fig. 328.

All cuticular ornamentation appears to be absent from the tail and head end of the male.

The head end of the female is wider and more rounded than that of the male. At a distance of 0·65 mm. from the anterior extremity of the former, *i.e.*, just in front of the vulva, the breadth is 0·16 mm., whilst the diameter measured at the same distance in the case of the male is only about half of this, being 0·085 mm. Park[1] stated that he obtained from the pus of a "tumour," by washing, a head which (he said) agreed in all particulars as regards size and shape with the rest of the parasitic worm, but until more than one was obtained he could not be certain that it did belong to that worm. This head was stated to have "teeth-like projections and briar-like barbs encircling in a spiral manner in numerous rows . ." We cannot find anything resembling Park's description. If his observation[2] be correct, then the head cannot belong to this worm. Unfortunately we have not succeeded as yet in finding the tail-end of a female though we have obtained many male tail-ends. These taper gradually and end in a fine rounded extremity (fig. 3), the posterior end being somewhat loosely spirally coiled.

The mouth is small, rounded and terminal, and appears to be surrounded in the female by three slight projecting lips. In the male, however, there was no trace of labial structures. The œsophagus is long, its lumen being very narrow. It extends backwards to the region of the vulva, where it forms a small pyriform structure rounded at the anterior end, and whose transverse diameter is only slightly

[1] Barnard and Park, *Report Aust. Assoc. Adv. Science*, v, 1893, p. 644.

[2] On reconsideration we believe that Park really saw a larval pentastome (*P. denticulata* = *Linguatula serrata*). This would further support the view expressed in our previous paper that the tissues from different parts of affected animals examined by these authors were hopelessly mixed, the part in which the pentastome was found being almost certainly a mesenteric gland, which was possibly also tubercular.

greater than that of the gullet. This appears to represent a cardia, an organ which is stated to be rare in species of Filaria. The intestine passes back as a fairly wide tube. Its course may be straight, sinuous or at times looped. The anus in the male is situated at about 0·72 mm. from posterior extremity. The excretory system was not recognised. The nerve ring is a well-defined structure surrounding the œsophagus at about 0·18 mm. from the anterior end. The dermis of the body wall is relatively thick when compared with the muscle cells.

Special Characters of the Male.—The male worm, as mentioned above, is much thinner than the female and has a more delicate cuticular ornamentation. There is no depression of the body surface corresponding to that in the region of the vulva in the female. There are two unequal spicules. The larger is arcuate with a twisted stem and a sharp pointed extremity. The proximal end is enlarged as is usually the case. The length is about 0·197 mm. The second spicule is 0·082 mm. long (indicated by dotted lines in fig. 3), its distal termination being swollen and rounded. The cloaca is situated on a median prominence about 0·065 mm. from the end of the parasite. On each side of it are four blunt prominent papillæ which are peri-anal in position. There is a pair just near the caudal extremity, and at about midway between these and the hindmost of the peri-anal there is situated another pair. There is thus a total of six pairs. At the caudal extremity is a slight rounded bilobed structure which perhaps represents still another pair of papillæ. The arrangement of the papillæ is very much like that figured by Parsons[1] for *Filaria volvulus*. The gonad is double.

Special Characters of the Female.—The vulva is situated in a shallow depression at about 0·8 mm. from the anterior

[1] A. C. Parsons, *Filaria volvulus*, etc., *Parasitology*, 1, 1908, p. 366.

end. Vaginal glands are present. The vagina is short and leads back into the large common uterine tube. The proximal part of the uterus may be considerably distended (fig. 1) by the mass of contained embryos. The main tube is a wide organ (0·07 mm. diameter) passing back for about 2·2 mm. where it bifurcates, each half being crowded with embryos. In some of the fragments they contain eggs, usually with a vermiform embryo within each, whilst in other fragments parts of the paired ovaries may be seen.

In our preliminary communication we stated that the worms were ovoviviparous and viviparous, but as a result of having examined more material we think that *F. gibsoni* normally is viviparous. As mentioned above, the uterus is crowded in its lower parts with free embryos, whilst further back eggs containing worm-embryos are mingled with the free embryos. We have seen the young worms escaping through the vulva. In two instances, however, we saw embryo-containing eggs in the vaginal region.

If a fresh "worm-nest" be cut across and a smear[1] be made from the cut surface, eggs and embryos in various stages of development will be met with. Apparently the ova after fertilisation develop very rapidly, the embryos being stored up in great numbers until a favourable opportunity for their liberation arises.

The fully developed embryo may be seen closely coiled up in its thin rounded or elliptical shell of about 0·03 by 0·045 mm. dimensions (fig. 3). Later, the little worm becomes free in the uterine cavity, the shell perhaps becoming absorbed as we have not noticed any empty egg-cases.

Its length now varies from 0·22 to 0·27 mm., being usually about 0·25 mm., the breadth being 0·003 to 0·004 mm. The anterior end is blunt and almost straight, the tail

[1] We have found Giemsa's stain to give the most satisfactory results.

being rather short but very thin and pointed. The œsophagus could be traced back for a short distance. The anus appears to be situated at about 0·021 mm. from the posterior end. The nerve ring is located relatively far back, being 0·07 mm. from the anterior end. The cuticle is very finely ringed, a few being indicated in the figure. Barnard and Park[1] drew attention to these very delicate structures and devised an ingenious method of using them to obtain the total length of the adult. They found that there were at least four hundred transverse striæ on the embryo, and on the supposition that these markings must necessarily become separated to form the striae of the adult, they argued that the multiplying of the distance between any two embryonic striae by 400 should give a rough estimate of the average length of the worm, viz., 36 inches. This agrees fairly well with our estimation of the length especially when one takes into consideration the fact that the striae of the embryo are very small and closely placed, and therefore hard to measure accurately. Any slight error must therefore become considerably accentuated when multiplied by 400. Our examination indicates that there must be many more than 400 rings in an adult worm, and this fact, together with the crowding together of those near the head end, at once discounts this method of estimating the total length. Barnard and Park gave the length of the embryo as being about one hundredth of an inch. Gibson's[2] measurements are 0·004 mm. wide by 0·25 mm. long. The embryos are capable of active movement in water for hours after their extraction from the nodule.

Filaria Nodules in Camels.—We have examined some similar filarial nodules obtained by one of us from two dromedary camels imported into West Australia from India.

[1] Barnard and Park, *loc cit.*, pp. 644-5.

[2] Gibson, *Trans. Intercol. Med. Congress of Australasia*, 1892, p. 579.

Owing to the fact that they had all been preserved in formalin, we had greater difficulty in making a thorough examination of the worms. The anterior end and body fragments show the same characters and measurements as those from the ox. The vulva is similarly placed. The ornamentation is alike, and the embryos are similar in regard to the head and tail ends and the annulations. We did not find any male specimens and consequently cannot absolutely identify the filaria from the camel as being specifically the same as that from the ox, though we have little doubt as to their identity since they agree in all points of comparison in regard to the female worms and in the subcutaneous habitat of the nematodes.

Comparison with other Camel filariæ.—The finding of this parasite in camels raises the question of its identity with *Filaria evansi*, Lewis. Apart from the differences in location of the parasites in their hosts (Lewis[1]) mentions that the adults of *F. evansi* were found in tangled masses plugging the pulmonary arteries, and were also present in the mesentery, we cannot find, in the meagre descriptions of the adults of *F. evansi* which are available to us, any references to a cuticular ornamentation comparable to that of our parasite or *F. reticulata*, features so striking as to at once arrest attention. Portions of an adult male filaria, presumably *F. evansi*, were taken from a bronchial tube of one of the West Australian camels. On examination it was seen that though it possessed fairly prominent annulations, yet it lacked the distinctive structures above referred to, and moreover the relations of the various parts at the head end were unlike in the two parasites. It was at first thought that this worm might be *Strongylus filaria*, Rud., a nematode which has frequently been found in camels in India, but this was not the case. We have also compared

[1] T. R. Lewis, *Proc. Asiatic Soc. of Bengal*, March 1882, p. 63, quoted in *Journ. Trop. Vet. Science*, II, No. 1, 1907, p. 151.

the embryos from the camel nodules with those taken by one of us from the blood of various camels in the same part of West Australia. These embryos[1] of *F. evansi* are of about the same length (0·23 mm.), but are much broader (0·006 mm.). In addition the tail is relatively larger and has a rounded end, whereas in the embryos of *F. gibsoni* it is very finely pointed. Then again the relations of the nerve ring and anus are different. Fine annulations are present in both.

E. and E. Sergent[2] mention that in Algeria a filarial embryo occurs commonly in the blood of camels which show subcutaneous abscesses, the latter being possibly due to the death and disintegration of the parent worms. The size of the embryos is given as 0·25 mm. long by 0·008 – 0·01 mm. in width with an obtuse anterior extremity and a moderately tapering tail. Thus these do not agree with our parasite. F. E. Mason[3] met with similar embryos in an Egyptian camel also affected with abscesses, but failed to find any adult worms in these though he succeeded in finding filariae allied to *F. equina*, Abildg (syn. *F. papillosa*, Rud.), in the blood-vessels of the male genitalia.

Comparison with certain bovine and other filariæ.—T. A. Ford[4] called attenion to the presence of "aortic worms" producing tumours in Malayan buffaloes. These parasites (Filariidae) were much more fully described, though not named, by G. L. Tuck,[5] who also noted a somewhat similar condition produced by another worm (also belonging to the

[1] It may be worth noting here that specimens of embryos of *Filaria evansi* were taken in one instance from a camel of only a month old (West Australia). This is almost certainly an instance of placental transmission.

[2] Ed. and Et. Sergent, *C. R. Soc. Biol.*, LVIII, 1905, p. 672, quoted in abstract in *Journ. Trop. Vet. Science*, II, 1907, p. 150.

[3] F. E. Mason, *Journ. Compar. Pathol. of Therapeutics*, XIX, 1906, p. 118, quoted in abstract in *Journ. Trop. Vet. Sci.*, II. 1907, p. 149 - 150.

[4] T. A. Ford, *Veterinary Record*, June 14, 1903, quoted by Tuck (5).

[5] Gnoh Lean Tuck, "Studies from Institute of Medical Research, Malaya," reprinted in *Journ. Trop. Vet. Sci.*, II, 1907, pp. 69 - 100.

Filariidae) in bullocks (Indian and Siamese). Both of these nematodes are quite distinct from *F. gibsoni*.

It is quite distinct from *Filaria labiato-papillosa*, Alessandr., (syn. *F. cervina*, Dies.) which occurs in the peritoneal cavity and adjacent connective tissues of cattle and various deer (*Cervidae*).[1] This parasite does not possess the cuticular ridges of *F. gibsoni* and has a quite different arrangement of papillae, being closely allied to *F. equina* of the horse.

It is now time that we should compare *F. gibsoni* with *Spiroptera reticulata*, Dies, or better, *Filaria reticulata*, on account of the position of the vulva and of other filarial characters. This species was first described by Diesing in 1841 and made a type of a new genus *Onchocerca*, Dies. The generic characters (freely translated) as given by him[2] are as follows:—Body filiform; male loosely spiral; female twisted into a close spiral; head continuous with the body; mouth terminal, orbicular; caudal extremity of the male excavated below and provided with two vertical lobes the base of each of which possesses a great number of small hooks and a papilla on the upper margin of each lobe; filiform penis between the lobes; female attentuated and genital aperture situated anteriorly, etc. The type species O. *reticulata*, Dies., is designated thus:—Body of female superficially delicately reticulo-annulate; male, length 1·5 cm., diameter 0·125 mm.; female, length 1·5 cm., diameter 0·25 mm. The host given is the horse. *Filaria reticulata*, Creplin, 1846, is given as a synonym. Dujardin,[3] Schneider,[4] and von Linstow,[5] do not mention the species. Davaine,[6]

[1] Railliet, *loc.cit.*, p. 526-7.

[2] Diesing, 1841, quoted in his "Systema Helminthum," II, 1851, p, 287.

[3] Dujardin, Hist. Nat. des Helm. ou Vers intestinaux, 1845.

[4] Schneider, Monographie der Nematoden, 1866.

[5] Von Linstow, Compendium der Helminthologie, 1878; and Supplement, 1889.

[6] Davaine, Traité des Entozoaires etc., Paris, 1877, p. 103.

Railliet,[1] Neumann[2] and Law[3] give an almost literal translation of Diesing's description, but add *Spiroptera cincinnata*, Ercolani, (*S. cincinnati* in Law) to his list of synonyms. The various authors state that the parasite is peculiar to equines.

From the above it appeared that all the helminthologists who had touched on the parasite and whose works were available to us, had accepted Diesing's statements regarding the structure of the male worm. Accordingly we had no option but to separate our worm from *F. reticulata*. Since the publication of our preliminary note, in which we, like Barnard and Park, drew attention to the marked similarity of the adult worms (especially the females), we have had access to Pader's[4] paper on "Filariose du Ligament suspenseur du boulet chez le cheval," published in a journal which was not previously available in Australia. He dealt with the anatomy and histology of *F. reticulata*, and gave an account of the earlier references to the finding of this nematode. In his description he shows that the males of *F. reticulata*, like other Filaridæ, possess two unequal spicules instead of one as described by Diesing, but these are considerably longer than those of *F. gibsoni*. Besides this the arrangement and size of the papillae as given by Pader are quite different from those of the male of our worm.

C. W. Stiles,[5] in discussing the zoological characters of the genus *Filaria* Müller, points out that the type species *F. martis*, Gmelin, has a cuticle which possesses neither bosses nor striations. Hence, if the large genus *Filaria*

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[1] Railliet, *l.c.*, p. 538-9.

[2] Neumann, Parasites (2nd English edition), 1905, p. 552-4.

[3] Law, Veterinary Medicine, v, 1903, pp. 439 - 440.

[4] J. Pader, "Arch. d. Parasitologie," IV, 1901, p. 58 – 95.

[5] Stiles, C. W., Bull. 34, Hyg. Lab. Public Health, Mar. Hospital Service, Washington, U.S.A., 1907, p. 32 – 36.

be split up (as has been done) into various subgenera, now generally regarded as genera, the members of the subgenus (or genus, *sensu stricto*) *Filaria*, should possess a similar cuticle to *F. martis*. *F. reticulata*, *F. volvulus* and *F. gibsoni*, could not accordingly be included. Diesing's generic name *(Onchocerca)* with *F. reticulata* as type is still available, but his generic diagnosis in view of Pader's work, would need to be corrected in that the males possess two unequal spicules. *F. gibsoni* and *F. volvulus*, Leuckt., would come under the genus amended as suggested.

It may not be out of place to recall the resemblance between the subcutaneous tumours produced in human beings by *O. volvulus*, to those caused by *O. reticulata* in horses,[1] and especially to those produced by *O. gibsoni* in cattle, and also to the worm tumours in camels. Besides this, the three parasites are very closely allied. The cuticular ornamentation is similar in all of them. Some excellent figures of *O. volvulus* are given by Fülleborn[2] and reproduced in an article on human filariæ by Fülleborn and Rodenwaldt.[3] The arrangement of the perianal and postanal papillæ is seen to be different from *O. gibsoni*. Parsons[4] has recently shown that the number and position of the papillae are different to those given by Fülleborn and very closely resemble those found in *O. gibsoni*. The shape of the spicules in these parasites is very similar. Our specimens were prepared according to the method advocated by Looss, and by Leiper.[5] Type slides have been presented to the Australian Museum, Sydney, co-types being retained by the Bureau of Microbiology, Sydney.

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[1] Pader, *l.c.*, p. 80.

[2] Fülleborn, F., Beiheft 7, zum Arch. f. Schiffs u. Tropenhygiene, XII, 1908, p. 15 etc.

[3] Fülleborn, F. and Rodenwaldt, E., "Filarien" in Real-Encyclopädie der gesamten Heilkunde, Aufl. 4, p. 81 etc.

[4] Parsons, *l.c.*, p. 364–366.

[5] Leiper, Wellcome Research Labs., Khartoum, 3rd Rept,, 1909, p. 187.

Suggested means of transmission of the disease.—By analogy with *Filaria bancrofti*, Cobbold (*F. nocturna*, Manson) of man, an intermediate host might be expected to be the agent of transmission from animal to animal. Such a host would most likely be a species of mosquito, perhaps a biting fly, or possibly a tick, all being animals which pierce the skin and suck blood. Since the tumours are, in most instances, well below the surface of the skin and their capsules are thick, it would further be necessary for the embryos, set free from the mother, to escape into and be present in the general circulation. As the embryos would be extruded from the vagina of the parent into the serous or sero-sanguinolent fluid present in the innermost sac, they would require to pass out from this by way of the lymphatics, or through the small vessels after piercing them. Gibson describes finding the embryos both in the capsule of the worm-nests and in the trabecular network, the majority being in lymphatic spaces, but occasionally some were found in the interior of blood-vessels. Though, as this author has pointed out, the fibrous capsule and trabeculae are well supplied with blood-vessels, we have not noticed any large and definite vascular trunks escaping from the nodules. This abundant blood-supply is therefore probably obtained by small vessels piercing the capsule at many different points, and by these and by the lymphatic connections, the embryos could enter the systemic circulation. Gibson failed to find the embryos in the general blood stream, but adds that his observations were very imperfect. Barnard and Park refer, in an addendum to their paper, to finding "young *Spiroptera* in some of the blood-vessels" but do not state whether in those of the general circulation or of the wall of the worm-nodule.

We ourselves, in sections of the growths, have seen the embryos free in the fibrous stroma surrounding the coils of

the parasite and also in the layers of the outer capsule nearest to the centre, but have not detected them towards the periphery. So far, we have not found any in the lumina of small blood-vessels, those present, which were usually straight or sometimes slightly coiled, lying in the fibrous stroma presumably in lymphatic channels. Smears made by shaving off layers of the outer capsule, have shewn occasional embryos before the central worm-mass was reached. We have examined, with negative results, the following series of thick blood films, stained after removal of the haemoglobin by distilled water. These films were all taken at night (6 p.m. to 2 a.m.) in case of nocturnal periodicity of the embryos.

1. From ear of bullock:—Worm-nest on breast about sixth rib. Supposed to come from Northern Territory of South Australia.
2. From ear of bullock:—Worm-nests on both breasts about fifth rib.
3. From foot of bullock:—Two large worm-nests one on each breast about fifth rib. Upper Hunter River, New South Wales.
4. From foot of bullock:—Worm-nest buried in flesh at point of brisket and fourth rib.
5. From ear of bullock:—Worm-nests on each brisket from second to eighth rib. Queensland bred.
6. From foot of bullock:—Worm-nest embedded in flesh of brisket about second rib. New South Wales.
7. From foot of bullock:—Worm-nests on brisket. Queensland.
8. From foot of bullock:—Large worm-nests on each brisket, about fourth rib. Upper Hunter River, New South Wales.

9. From ear of bullock:—Worm-nests on brisket. Upper Hunter River, New South Wales.

10. From ear of bullock:—Worm-nests on both briskets, sixth and eighth ribs. Queensland.

Twelve similar films from infected cattle, taken from the aortic blood during the day time (6 a.m. to 3 p.m.), were also negative.

It may be that the embryos can only escape in numbers into the circulation before the fibrous capsule has become much thickened, and hence would be found in this situation in only an occasional animal. It is obvious that, if certain *Diptera* are the intermediate hosts, embryos must, at one time or another be fairly numerous in the peripheral blood of certain animals at least, if the frequency of the infection is to be accounted for. Our results, however, do not support this hypothesis.

On the other hand quite another analogy presents itself in connection with the guinea-worm (*F. medinensis*, Velsch) of man. This worm after working its way through the tissues, eventually reaches a dependent situation such as the leg, where, after piercing the skin, it finally extrudes its embryos which escape into a fluid medium. A species of *Cyclops* or other freshwater crustacean probably then serves as an intermediate host, and later the developing parasite enters the human system in drinking water. Several points suggest that a similar life-cycle may occur in this cattle Filaria. One is that the worm-nests are almost always found in the subcutaneous tissues (we have a specimen in which the dermis itself is considerably thinned by the presence of the developing nodule), and especially in those over the brisket, a part of the body which would come in fairly close contact with the ground or a fluid medium when the animal was lying down or wallowing in water or mud. Another is that the screw-like external

bands round the body of the worm, are eminently suited for aiding its progress through the tissues of the host, the animal actually boring its way along. Such an architecture, indicating, we believe, the necessity for translation of the animal in the host's body, would be an extravagant waste in the case of a Filaria which merely had to extrude embryos into the circulating blood and to whom practically all the fibrous tissues, internal and external should be equally advantageous for its development.

This second theory is beset with a grave difficulty, however, which consists in the dense fibrous capsule which surrounds the worm, especially in the older nodules, and which is evidently a reactive process on the part of the tissues of the host to the irritative presence of the parent worm or of its struggling embryos. It can hardly be imagined that the adult form can escape from such a prison to wander to the surface and extrude its embryos. We are not at all certain, however, that this imprisonment in a thick capsule is the normal fate of the Filaria. We think that it is quite possible that, on their way to the surface and especially when the sexes are in conjugation, a certain number, perhaps many, of the adult worms, as the result of the irritation to the tissues that their progress through them produces, are arrested and finally surrounded by a fibrous capsule, which becomes thicker as time advances but which still leaves the worm and its embryos alive in the centre.[1] Those females, on the other hand, which escaped this fate, would reach the surface, pierce the epidermis, and liberate their embryos without perhaps doing any noticeable damage to the hide or attracting the attention of the slaughterman. An intermediate stage of the

[1] Manson ("Tropical Diseases," 3rd Edit.. 1903, p. 624) refers to the premature death in man of *F. medinensis* with the formation of abscesses or calcified cords, conditions somewhat analagous to the worm-nests of *F. gibsoni*.

life history would then probably occur in some fresh-water animal and the re-introduction of the parasite take place through drinking water containing these. So far we have not succeeded in finding the embryos alive after having been in water for more than a few days.

Escape of the embryos from the nodules through the agency of ingestion by a carnivorous animal can practically be excluded. Dingoes (*Canis dingo*) are the only animals in Australia that could play this rôle, and they could only do so by eating the nodules from a bovine that had died by accident in the bush, a comparatively rare event. Further, Dr. Gibson fed a young pup on minced worm-nests and bread for 15 weeks. On killing the animal 24 hours after eating its last meal of this nature, he found no nematode embryos in the blood and no living embryos in the stomach or intestines, though numbers of partly digested ones were found in the stomach and duodenum.

Barnard and Park's suggestion of direct transmission of the parasite we consider highly improbable. If such be the case, one would expect that animals harbouring a worm-nest would later develop an enormous brood of young nodules. One of our colleagues, Mr. G. P. Darnell-Smith, has, however, inoculated a number of living embryos into the subcutaneous tissues of a calf six months old and into a rabbit. As the former was only inoculated a short time ago, no results can yet be expected. The rabbit was also inoculated, but no embryos could be seen in blood smears taken four months later.

Fülleborn[1] and Rodenwaldt[2] in dealing with *O. volvulus*, mention that the embryos (which are similar in appearance to those of *O. gibsoni*) have not yet been found in the blood, though Brumpt[3] found them in the peripheral parts of the

[1] Fülleborn, *l.c.*, p. 15. [2] Fülleborn and Rodenwaldt, *l.c.*, p. 83.
[3] Brumpt, quoted by Fülleborn, *l.c.*, p. 15, 17.

tumours and thinks that they reach the lymphatics and finally the general circulation, and that consequently the transmitting agent might be a biting insect (*Tabanus*, *Glossina*, *Simulium*). He believes that transmission of *O. reticulata* occurs in the same way. As stated above, we have not succeeded in finding embryos of *O. gibsoni* in the blood of cattle.

Parsons[1] mentioned that in the case of *F. volvulus*, the parasite lives in a local dilatation of a lymphatic, and that the embryos probably pass from these into the general circulation, but that no observer had yet detected the microfilariae in the blood. By analogy, he considered the transmitting agent to be some blood-sucking insect.

ADDENDUM :—While this paper was in the press, one of us received from Professor A. Railliet of Alfort, France, amongst a number of reprints, a paper dealing with "Les Onchocerques etc." by Railliet and Henry (*C.R. Soc. Biol. Paris*, LXVIII, 1910, p. 248–251). In this note the authors cover some of the ground that we do in the above paper. They re-establish Diesing's genus *Onchocerca* with *O. reticulata*, Dies. from the foot of the horse as type, making a new species *O. cervicalis* for the parasite infesting the cervical ligaments of the same animal. *Filaria volvulus*, Leuckt. is also brought into this genus. A fragment of a female nematode taken from a worm-nest from the subcutaneous tissues of the head of a dromedary in the Punjab, by A. S. Leese, is described as belonging to a new species *O. fasciata*. The only information given concerning it is that the breadth is from 403 to 475μ, and that the cuticle possesses feebly undulating ridges repeated at every three or four striae. We have compared the *Onchocerca* (females) taken from the West Australian dromedaries, with that from local cattle, and notice that in the former the ridges

[1] Parsons, *l.c.*, p. 366-7.

are closer, lower and less pronounced than in the latter. Besides this transverse striae are present. The diameter of the female body in most of the segments examined was about the same in each case namely from 180 to 400 μ, more usually approximating the latter figure. We are able then to record the finding of at least two species of *Onchocerca* in Australia, viz., *O. gibsoni* in cattle and *O. fasciata* in camels.

During the past few days we have received the "Annual Report of the Veterinary Officer investigating Camel Diseases, for the year ending 31 March, 1910," by A. S. Leese, who on page 13 mentions the finding of *O. fasciata* fairly commonly, coiled up in nodules in the subcutaneous tissues. He goes on to say that the parasite does not cause any perceptible harm to its host. We might add that the first reference to the presence of this nematode (at that time unidentified) appears to have been made in 1909 by one of us, who found them in 1907 in dromedaries recently imported into West Australia from India (Cleland, Bull. 34, Dept. Agric., West Austr., 1909, p. 8).

EXPLANATION OF PLATE.

Onchocerca gibsoni, Cleland and Johnston.

Fig. 1. Anterior end of female.
Fig. 2. Portion of body of female, shewing pattern on cuticle. A few longitudinal striæ are also represented.
Fig. 3. Posterior end of male.
Fig. 4. Embryo in shell (drawn from a smear preparation).

All the above sketches were made with the aid of a camera lucida. Nos. 1 and 2 are equally magnified.

References to lettering:—*b.w.*, body wall (dermis and muscle); *a*, anus; *a.e.*, anus of embryo; *cu.*, cuticle; *cu.r.*, cuticular ridges; *emb. sh.*, embryonal shell; *int.*, intestine; *l.str.*, longitudinal striæ; *m.*, mouth; *m.m.*, muscles attached to spicule; *n.r.*, nerve ring; *n.r.e.*, nerve ring of embryo; *o.e.*, oesophagus of embryo; *oes.*, oesophagus; p_1, caudal papilla? $p_2 p_3$, post-anal papillae; p_4 four peri-anal papillae; *r.e.*, rings on cuticle of embryo; *sp.* 1, *sp.* 2, (dotted) spicules of male; *ut.*, uterus (main trunk); *ut.*$_1$, *ut.*$_2$, uterine branches; *v.*, vulva; *vg.*, vagina.